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ABSTRACT

Unlike the past models guiding cross-cultural psychological research, a new paradigm facilitates multiple level investigations by incorporating both culture-specific (nested) and culture-general (crossed) independent variables within its partially-hierarchical framework. Based upon the generalizability analysis, this model generates sequential tests of alternative hypothesis so that the veridical level of generality or specificity of human behavior can be succintly assessed. Having empirically determined the veridical level of generality, the researcher can then employ a regression equation which is congruent to the level of generality found. Through the use of Bayesian techniques and inference, the new paradigm can produce posterior distributions for the variance components and generalizability statistics in order to evaluate their reasonableness. Similarly, the Bayesian approach incorporates information concerning the level of generalizability in tests between any or all of the cultural means on the dependent variable. (Author/CTM)

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A NEW PARADIGM FOR CROSS-CULTURAL PSYCHOLOGICAL RESEARCH

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STATEMENT OF THE PROBLEM

One primary concern for the cross-cultural study of psychological processes focuses upon the validity of the theories and findings drawn from one setting, population, and culture for any other setting, population, and culture (Triandis, 1972). This concern addresses the question of whether statements concerning human behavior should be quite general and at the level of all cultures or quite relative and at the level of a specific culture (Bendix, 1963). In order to assure the veridicality of these statements, the psychologist must be able to investigate the dependent variable(s) of interest at multiple levels (i.e., culture, subcultural, and individual differences) of analysis. This multiple level framework would permit the psychological researcher to be able to test the alternative hypotheses to those held initially. Thus if the researcher initially assumed that the behavior in question was quite general, the multiple level framework would enable the researcher to test the alternative hypothesis that it was quite specific. Unfortunately, as is pointed out by Przeworski and Teune (1970), the paradigm which has traditionally guided cross-cultural psychological research has not facilitated multiple-level investigations. Rather, it was characteristically quite restrictive in forcing a researcher to investigate a psychological process either at the level of specific cultures (Cole and Scribner, 1972), or at the level of all cultures

(Rohner, 1975; Brislin, Lonner, and Thorndike, 1973; McClelland, 1961). This bifurcation of cross-cultural psychological research into two mutually exclusive processes has thus led to all manner of assumptions (Campbell, 1970; Malewski, 1961), theories (Rosch, 1975; Berry, 1975; and models (Triandis, 1975; Miller, 1970) whose veridicality cannot be assured since they are not derived from multiple level investigations. In recognizing, the overwhelming restrictiveness of this traditional paradigm, some cross-cultural researchers, notably Przeworski and Teune (1970) and Eckensbarger (in Nessleroade and Reese, 1972) have called for a new, multiple level approach to cross-cultural research, but have not provided any model with which to integrate the multi-level investigative process.

However, Evans (Note 1), in applying the Generalizability framework (Cronbach, et al., 1972) in terms of a partially-hierarchical design (Winer, 1971) and Bayesian inference (Box and Tiao, 1973), has developed a paradigm from which to conduct multiple-level cross-cultural investigations, determine the veridical level of generality or specificity, determine the reasonableness of the results, and co-terminously assure the equivalency of measurement across the participating cultures. While this Bayesian and Generalizability approach to cross-cultural research in its entirety entails many topics and issues, it is the purpose of this paper to present a few of the key developments so as to facilitate multiple level investigations by other cross-cultural psychological researchers. Specifically, the issues to be addressed by this paper are:

1. The sequential strategy derived from the results of a multi-factor partially-hierarchical Generalizability analysis of cross-cultural data, in terms of the decisions to be made as to each alternative hypothesis.

2. The four possible regression equations (each congruent with a different level of generality or specificity) with which an investigator could predict the dependent variable of interest. Also, the formula for calculating regressed estimates of $\sigma^2(\delta)$ for each culture.

3. The testing of mean differences between cultures (and socio-cultural groups) in the light of any empirically derived generalizability coefficient (ρ^2) and the "collateral information" incorporated in this coefficient.

4. The establishment of the cross-cultural validity for a psychological construct through some multivariate Generalizability techniques.

5. Formulae through which a cross-cultural psychological researcher could determine the posterior density (believability) function for the generalizability statistics such as the generalizability coefficient (ρ^2).

METHODS AND STATISTICAL PROCEDURES

I. Theoretical Framework and Model

The four aforementioned statistics and measurement strategies can be illustrated with a hypothetical cross-cultural study[1] on attributional behavior. A social psychologist could be interested in the attributional behavior of students in situations where they have all experienced "success" relative to their performance on a task. Having designed equivalent measurements of attribution for several cultures, let's assume the researcher is concerned as to whether "success-attributions"can be accounted for solely in terms of individual-differences in achievement motivation or if they were dependent upon an individual's ethnic membership or cultural differences. Likewise, let's assume the investigator is interested in whether there are any age or developmental differences in "success-attribution" behavior. In short, the investigator is concerned with now far statements concerning "success-attributions" could be generalized and the limitations imposed by cultural, ethnic, or age differences. The ANOVA model implied is that of a prtially-hierarchical design (Winer, 1971) with two nested factors (i.e., culture and ethnicity) and two crossed factors (i.e., age and achievement motivation level). Letting "C" represent the cultural facet, "E" represent ethnicity, "T" represent levels of

achievement motivation, and "A" represent age level, this design, in Cronbach et al. (1972) notation, is (E:C) X A X T.

The linear model describing this hypothetical investigation on "success-attributions" could be given as follows:

$$Xceai = \mu + \alpha_{\underline{c}} + \gamma_{\underline{\varepsilon:c}} + T_M + \beta_{\underline{a}} + \alpha\beta_{\underline{ca}} + \beta\gamma_{\underline{a\varepsilon:c}} + \alpha T_{\underline{cm}} + \beta T_{\underline{am}} + \alpha T\beta_{\underline{cam}} + \gamma T\beta_{\underline{\varepsilon:cam}} + \beta\pi_{\underline{ap:\varepsilon:c}} + e_{\underline{o}}(ap:\varepsilon:c$$

where:

μ = grand mean "success-attribution"

$\alpha_{\underline{c}}$ = effect for culture

$\gamma_{\underline{\varepsilon:c}}$ = effect for ethnic group nested within culture

T_M = effect for level of achievement motivation

$\beta_{\underline{a}}$ = effect for age level

$\alpha\beta_{\underline{ca}}$ = interaction of culture and age level

$\beta\gamma_{a\varepsilon:c}$ = interaction of culture and age level

$\alpha T_{\underline{CM}}$ = interaction of culture and achievement motivation level

$\gamma T_{\underline{M\varepsilon:c}}$ = interaction of ethnic group at achievement motivation level

$\beta T_{\underline{am}}$ = interaction of age level and achievement motivation level

$\alpha T\beta_{\underline{cam}}$ = interaction of culture and eye level and achievement motivation level

$\gamma T\beta_{\underline{\varepsilon:cam}}$ = interaction of ethnic group and age level and achievment motivation level

$\beta\pi_{\underline{ai}:\underline{\varepsilon}:\underline{c}}$ = within-cell variation (Winer, 1971) confounded with $(\underline{e}_{\underline{o}(ap:\varepsilon:c)})$

The ANOVA model given above is assumed to follow a random effects model based upon the postulate of exchangeability (Novick and Jackson, 1974; Winkler, 1972; Turner, 1967; Kaplan, 1964) and that the prior density functions for each of the facets in the study do not express perturbations around any specific point (Box and Tiao, 1973; Zellner, 1971).

II. Sequential Decision Strategy

The assessment of the veridical level of generality (or specificity) proceeds in a sequence of four sequential steps, at each step investigating the generalizability coefficient for a different level in the study. These four steps correspond roughly to the levels of the individual-actor, subcultural, and culture ("systemic") as suggested by Przeworski and Teuen (1970). The decision process begins with the computing of the variance components for each of the terms produced by the partially-hierarchical ANOVA. These components for the independent variables each are then transformed into generalizability coefficients using as an error term ($\sigma^2(\delta)$) as any interactions the independent variable of interest has with any other variable. In terms of the hypothetical ANOVA above, the following generalizability coefficients could be derived as follows:

$$\rho^2(\text{culture}) = \frac{\sigma^2(\text{culture})}{\sigma^2(\text{culture}) + \sigma^2(\delta)} \quad (1)$$

where $\sigma^2(\delta) = \sigma^2$ (culture x age) + (culture x achievement motivation level) + σ^2 (culture x age x achievement motivation level) + σ^2 (within cell) (2)

(3)

where $\sigma^2(\delta) = \sigma^2$ (ethnic groups x age level) + σ^2(ethnic groups x achievement motivation levels) + σ^2 (ethnic groups x age level x achievement motivation level) + σ^2 (within cell) (4)

$$\rho^2 \text{ (age level)} = \frac{\sigma^2 \text{ (age level)}}{\rho^2 \text{ (age level)} + \sigma^2(\delta)} \quad (5)$$

where $\sigma^2(\delta) = \sigma^2$ (age level x culture) + σ^2 (agelevel x ethnic gorups + σ^2 (age level x achievement motivation level) + σ^2 (age level x culture x achievement motivation level) σ^2 (age level x ethnic groups x achievement motivation level + σ^2 (within cell) (6)

$$\rho^2 \text{ achievement motivation level)} = \frac{\sigma^2 \text{ (achievement motivation level}}{\sigma^2 \text{ (achievement motivation level)} + \sigma^2(\delta)} \quad (7)$$

where $\sigma^2(\delta)$ = σ^2 (achievement motivation level x culture) + σ^2 (achievement motivation level x ethnic groups) + σ^2 (achievement motivation level x age level) + σ^2 (achievement motivation level x culture x age level) + σ^2 (achievement motivation level x ethnic group x age level) + σ^2 within cell)

Before describing the sequential decision strategy into which these generalizability coefficients are put, it might be worthwhile to briefly discuss the meaning of generalizability coefficients of various sizes. Obtaining large generalizability coefficients for a particular independent variable represent high within-level correlations among the achievement motivation scores for that independent variable. Thus, a high generalizability coefficient for the independent variable of "age" would mean that within each age level (e.g. high school, college) there was a high degree of similarity of achievement motivation scores, but that there were large differences in achievement motivation scores across age levels. Thus, all discussions or statements concerning achievement behavior would have to be made specific to an individual's age level. This high generalizability coefficient would thus indicate that there was a high degree of generalizability of achievement motivation behavior across all other non-age factors included in the study (e.g., sex levels, cultural membership, eth-

nic group membership) achievement motivation level, etc.). Likewise a high generalizability coefficient for "culture" would indicate a high within-culture correlation among achievement motivation scores and coterminously it would imply a high degree of generalizability of achievement scores across the other non-culture facets included in the study (age, sex, achievement motivation level, ethnic group membership, etc.). Thus, a high generalizability coefficient for "culture" would imply that all statements concerning achievement scores would have to be made specific to each individual culture.

However, a low generalizability coefficient for a particular independent variable would indicate a lack of specificity in achievement motivation scores for that particular independent variable. This is because a low generalizability coefficient would express the lack of achievement score varience accounted for by that particular independent variable of interest. A low generalizability coefficient could mean that any within-level dependent variable relationship was attenuated by the variable accounted for by interaction (or other) terms

Having computed these coefficients, the researcher would then sequentially determine which level expressed accounted for the most variance of the dependent variable. The researcher's decision would be based upon the magnitude of the generalizability coefficient for each level in the study and the posterior model estimates to be done. The researcher would begin at what Przeworski and Teune (1970) define as the level of the individual-actor. The researcher would examine the magnitude of ρ^2 (achievement motivation) and in doing so, would decide whether the "success attribution" scores were explained solely in terms of individual differences and thus generalizable across age groups, ethnic groups, and cultures, or whether the explanation was to be more specific and relative. If the ρ^2 (achievement motivation) indicated that the individual subjects did not form a single homogeneous population (Rohner, 1976; Malewski, 1961), the researcher would continue to the next level: that of age group differences (subcultural level; Przeworski and Teune, 1970). In checking the ρ^2 (age groups), the researcher would be concerned whether, there was generality across cultures and ethnic groups but that the explanation of "success-attributions" had to be specific to each developmental level.

If there was a minimal amount of dependent variable variance accounted for by ρ^2 (ethnic groups), explanation of "success-attributions" could be generalized across persons in different developmental levels but specific to ethnic groups within each culture.

However, if ρ^2 (ethnic group) was small, the researcher would move to the level of the system or culture itself (Przeworski and Teune, 1970). If ρ^2 (culture) was large, it would indicate that certain characteristics unique to each culture accounted for the dependent variable. Triandis (1975, 1972) gives a list of some within-culture variables which could contribute to cultural differences.

III. Regression Equations Appropriate to the Level of Generality Found

With the determination (in part II) above of the veridical level of generality (or specificy), a cross-cultural researcher could be interested in employing equations to predict a dependent variable relative to the level of generality (or specificity) found empirically. Cronbach et al. (1972) have discussed four such levels of generality which could affect the development of the prediction equation. These can be recast in terms of a Bayesian inference in terms of the Lindley Structural Equation (1971) and Novack's Asymptotic Equation (1969).

It is necessary to illustrate the four precedingly defined cases of cross-cultural prediction situations and depict the modification of this equation to reflect the characteristics of each particular case. However, there are many characteristics, concerning the superiority of the predicted universe score score ($\hat{\mu}p$) approach of Generalizability theory vis-à-vis the traditional approaches reliance on observed scores. Before continuing with the presentation of more material concerning the cross-cultural prediction situations, it would be worthwhile briefly to summarize the extra benefits of adopting the present predicted universe score approach, especially in regards to its utility for cross-cultural research.

Summary of Advantages and Benefits of Predicted Universe Score Approach

1. The Bayesian regression equation based upon Generalizability theory incorporate all worthwhile and relevant information available into its predictions. As Novick (1969) and Lindley (1971) have emphasized, for any one individual's observed score, there is collateral information concerning that person's score from all the other individuals included in the study. Thus, having once collected information on several individuals (Xi), we actually have some information relevant to the scores of a newly measured

individual (Xs). The regression model proposed here would be able to utilize all of this information (full-information approach) in its predictions. Specifically, the information incorporated into the regression equation spring from three different sources. These sources are,

(a) individual's score(s),

(b) the scores or performance of the culture or group within which that individual is a member (Within-group information), and

(c) the information from members of other cultures or groups included in the study (Between-group information).

The traditional framework employed by Przeworski and Tuene (1970) can not incorporate all of their sets of information at once. Novick and Jackson (1972) see the use of these three pieces of information as critical to accurate predictions.

2. In line with the reasoning in Number 1 above, several researchers have shown an increase in precision of prediction through the use of this Bayesian full-information regression approach. Cronbach et al. (1972) have illustrated the increased precision in prediction by incorporating both within-group and between-group information into the same estimation equation. Similarly, Novick and Thayer (Note 5), Novick, Jackson, and Thayer (1971), and Jackson, Novick, and Thayer (1971) have shown the increased accuracy by adopting

the collateral information Bayesian approach. Finally, Shigamasu (1976) and Novick, Jackson, Thayer, and Cole (1971, 1972) pointed to the decrease in the mean square error of prediction when using the Bayesian regression model.

3. The regression equations based upon Generalizability theory also directly incorporated into their estimates the information regarding the veridical level of generality or specificity found through the sequential strategy and multiple-level analysis described in section one above. This incorporation is through the use of the generalizability coefficient-intraclass correlation coefficient--within the regression equation itself. The traditional paradigm could not use the degree of generality and specificity simultaneously in its estimates. Rather, as illustrated by Przeworski and Tuene (1970), several complex equations were required for each prediction, with some equations expressing the degree of cultural specificity and other equations reflecting the amount of cross-cultural generality. With this Generalizability theory approach, only one basic regression equation is necessary. No other additional equations are necessary since the Generalizability regression equation is simply modified in terms of the veridical level of generality or specificity of human behavior. Thus the resulting predicted scores will be in terms of the empirically determined level.

4. In line with the above point, since the generalizability coefficient (ρ^2) employed in the equation is also

composed of an appropriate $\sigma^2(\delta)$ term, the predicted scores will also reflect the effect of theoretically meaningful interactions between the independent variables included in the study. While these interactions will tend to reflect a particularizing effect in terms of the generality issue, the representation of their effects may be theoretically very meaningful and important. Examples of this importance of representing the interaction effects include the interaction between Evaluation Condition and G.P.A. level of Calili, Maehr, Sorenson, and Fyans (1976) and Sex x Grade x Evaluation Condition interaction of Kremer (Note 9). Other examples include the various Person x Situation interactions found in the personality and social psychological literature and as discussed by Bower (1973) and Golding (1975). The strength of these theoretically interesting interactions is explicitly expressed in the predicted scores via their inclusion in the definition of the generalizability coefficient.

5. The universe scores predicted by the regression equations are much more reliable than the observed scores predicted by the traditional methods (Cronbach et al., 1972). This increased reliability has three important implications for the use of cross-culturally collected data.

First, the interpretation of these predicted scores are much less susceptible to alternative hypotheses such as statistical regression which have been shown to be particularly

debilitating for the use or interpretation of cross-cultural data (Brislin, Lonner, & Thorndike, 1973; Triandis, 1972). Whenever data are collected from several distinct groups of individuals these types of hypotheses plague any use of the data. Thus the predicted scores can be used much more confidently than the traditional predicted observed scores. This is evident particularly in terms of norm-referenced or criterion-referenced interpretations (Irvine & Carroll, Note 10) or in terms of repeated sequential testing, difference scores or gain-change scores employed to detect cultural change and differentiation (Buss, 1973, 1975; Cronbach et al., 1972; Eckensharger, in Nessleroade & Reese, 1972; Labouvie, 1975; Schaie, 1965; Schaie & Strother, 1972).

Second, the predicted scores would express less of the effect of errors of measurement arising from the condition of non-equivalency of measurement across cultures. The error associated with this non-equivalence is divided out of the generalizability coefficient in the prediction equation. Thus, better decisions and interpretations could be made with these predicted universe scores to the extent that there was non-equivalency of the conditions of measurement.

Third, the researcher is able to make tighter confidence intervals for the scores predicted by these equations as compared with the traditionally predicted scores. The scores predicted by the generalizability equations are based

upon a scale with a standard deviation defined by $\sigma(\varepsilon)$. The observed scores predicted by the models of Przeworski and Tuene (1970) are based upon a scale with a standard deviation of $\sigma(\Delta)$. Cronbach et al. (1972) show that $\sigma(\Delta)$ is always smaller than $\sigma(\varepsilon)$ and thus the researcher can use the same level of confidence for the universe scores as with observed scores, but be talking in terms of a much shorter interval.

6. If the cultures do have different mean values or variances in terms of the dependent variable, the use of these equations can put the scores from all different cultures upon the same scale with the same standard deviation. This transformation of scores from all cultures to the same scale would greatly aid and facilitate the interpretation of cross-cultural differences since they would no longer be clouded by each different culture's own standard deviation or mean. Rather, all cultural differences could be viewed in terms of the universe score scale and its standard deviation. The standard deviation of the universe score scale would also be smaller than those of each individual culture.

7. Another advantage to this regression model concerns the use of prior information for a particular culture. This advantage becomes increasingly important if the level of specificity is so large that all statements and interpretations of a human behavior must be made relative to each specific culture. In this culture-specific situation (Case IV to be discussed shortly), the researcher may want to

modify the posterior modal (or mean) estimates of the universe scores of members of a culture by any culture-specific information that researcher feels is relevant. Thus, the researcher could modify the prior beliefs concerning the variance components in the design if it appeared that there were certain, very influential and theoretically important, normative (Triandis, 1972) or base-rate (Meehl & Rosen, 1955) type of phenomenon occurring within a particular culture. Thus the (Case IV) regression equation for each culture would be made even more unique to each culture due to the incorporation of the prior information.

8. Having obtained posterior modal (or mean) estimates of the universe scores for all the individual's within a cross-cultural study, the researcher could use the Box and Tiao (1968) techniques to derive the posterior correlations among these universe scores. Due to the use of the collateral information available and the regression to the mean, these posterior correlations will be larger than those from any prior ones based upon the observed scores alone. Since these posterior correlations are based upon more of the relevant information than the observed score correlations, they will be of more meaning theoretical importance to the cross-cultural researcher.

9. Finally, it is possible that a researcher may be investigating several dependent variables at one time. While the case of the multivariate extension of this Generalizability

approach will be discussed later, it is important to recognize that the present prediction format could also be used to reliably predict one dependent variable score from another. This technique would be based upon an adaptation of the equations as given by Lord and Novick (1972), and the work of Travers (Note 7) on the correction for attenuation in multivariate generalizability. Thus, if the researcher had studied the relationship between scores on an "Early Socialization Pattern" retrospective inventory and a measure of present achievement motivation cross-culturally as one independent and another dependent variable and wanted to be able to reliably predict one from the other, in the light of the cross-cultural generality or specificity, the researcher could employ an adaptation of these equations. A similar situation could arise if a researcher had studied both career and achievement motivation as dependent variables in a cross-cultural study, and wished to predict one from the other, relative to the level of generality or specificity and the collateral information available.

Having thus presented the advantages and benefits of the regression model based upon Generalizability theory and Bayesian inference, it is now necessary to illustrate the four different prediction situations which could arise cross-culturally and the equations to be used relative to these varying levels of cross-cultural generality and specificity.

Their four prediction situations and equations appropriate to them can be defined in terms of cross-cultural research in the following ways.

Case One: That the dependent variable is generalizable across all cultures, each culture having equal means on the dependent variable and equal variance errors of estimate[2] [$\sigma^2(\varepsilon)$].

$$R(\hat{\mu}_p|X_pI) = X_{pI} + \rho^2(\text{crossed}) \cdot (X_{pI} - X_{PI}) \quad (8)$$

where $\hat{\mu}_p$ = an individual's predicted universe score upon the dependent variable of interest (9)

X_{pI} = An individual's mean dependent variable score

$\rho^2(\text{crossed})$ = The coefficient of generalizability for the crossed variable with the greatest generality. (10)

Case Two: [illegible]itions same as above except that different cultures have different mean values on the dependent variable.

$$R(\hat{\mu}_p|X_{pI}) = X_{PI*} + \rho^2(\text{crossed}) \cdot (X_{pI} - X_{PI*}) \quad (11)$$

where X_{PI*} = The mean dependent variable score found for a culture across all individuals of that culture. (12)

Case Three: Conditions same as above except that different cultures have different variance error of estimates[2] and diffe

$$R(\hat{\mu}_p|X_{pI}) = X_{PI*} + \left[\frac{\sigma^2(\text{crossed})}{\sigma^2(\text{crossed}) + \sigma^2(\delta)^*}\right](X_{pI} - X_{PI*}) \quad (13)$$

where $\sigma^2(\text{crossed})$ = The large variance component for the crossed independent variable which is the same in each culture (14)

$\sigma^2(\delta)^*$ = The error variance present within each culture. (15)

Case Four: That there is no generality, whatsoever, across cultures, with each culture having its own mean, variance error of estimate,[2] and level of generality within that culture.

$$R(\hat{\mu}p|X_{pI}) = X_{PI*} + \rho^{2*} \cdot (X_{pI} - X_{PI}*) \quad (16)$$

where $\rho^2(\ )^*$ = the coefficient of generalizability in terms of an independent variable (crossed or nested) of interest computed separately for each culture in the study.

Cases three and four above, have different $\sigma^2(\delta)$'s for independent variables investigated. It was these sample values which were incorporated into the above regression equation. However, Novick and Jackson (1974) have recently taken issue with the use of sample values of error variances and argue for the use of regressed estimates of these variances. Based upon their development (Novick & Jackson, 1974), regressed estimates of $\sigma^2(\delta)$ could be obtained as follows:

First, define $\hat{\phi}i = \sigma^2(\delta i)$ for the "i" th culture (17)

Thus one $\hat{\phi}$ for each culture.

Further define

$ti = \ell n\ \hat{\phi}i + (Vi)^{-1}$ for the ith culture, thus one ti for each culture (18)

where $Vi = (ni - 1)$ or the degrees of freedom in each culture (one less than the number of observations) (19)

Further, assume that each

$$ti \sim N(\omega i,\ 2vi\text{-}1) \tag{20}$$

$$\text{where } \omega i = \ell n \phi i \tag{21}$$

And that

$$\hat{\omega}i \sim N(\mu\Omega,\ \sigma^2\Omega) \tag{22}$$

$$\text{where} \quad \mu\Omega = \frac{\Sigma wti}{wi} \tag{23}$$

and

$$wi = (\vartheta^2\Omega + 2Vi^{-1})^{-1} \tag{24}$$

and

$$\vartheta^2_\Omega = (m\text{-}1)^{-1}\ \Sigma(ti\text{-}t.)^2 - 2m^{-1}\ \Sigma^{-1}Vi \tag{25}$$

where m = The number of cultures in the study (26)

and

$$t. = m^{-1}\ \Sigma ti \tag{27}$$

Then,

$$R(\Omega|ti) = \hat{\omega}i = \frac{(\vartheta^2_\Omega)\ (ti) + (2\bar{Vi}^{-1})\hat{\Omega}\Omega}{(\vartheta^2_\Omega) + (2\bar{Vi}^{-1})} \tag{28}$$

Thus,

$\hat{\phi}i = \exp \hat{\omega}i$ for each culture (38)

Thus those regressed estimates of $\sigma^2(\delta i)$ would replace the sample values input into the regression equations of case three and four above.

IV. The Testing of Mean Differences Between Cultures

Box and Tiao (1973) and Novick and Jackson (1974) have shown that in conducting tests between the means of any groups, a researcher should incorporate as much information as possible concerning these groups (e.g., reliability of the means, etc.) into the mean comparisons. Testing the difference between the means of cultures is a major concern for the cross-culture researcher. The coefficient of generalizability found empirically for the dependent variable would supply the "collateral information" concerning the cultures as discussed by Box and Tiao (1973) and Novick and Jackson (1974). Thus, the tests for the significance of a single culture's mean and the differences between the means of cultures can be recast in the following ways.

Testing significance of the mean from a single culture.

$$\frac{\Theta_j - [(\rho^2)y_j \cdot + (1 - \rho^2 y \cdot .]}{\sqrt{[1+\frac{(1-\rho^2)}{(J)(\rho^2)} (\frac{s_1+s_2(1-\rho^2)}{Jk-1} \frac{\rho^2}{k}]}} \sim t_{Jk-1} \quad (29)$$

where ρ^2 = generalizability coefficient for the dependent variable (30)

$y_j.$ = sample value of the culture mean in question (31)

$y..$ = grand mean on dependent variable of all cultures in the study (32)

s_1 = within groups sum of squares (33)

s_2 = between groups sum of squares (34)

J = Number of cultures (35)

k = number of observations within each culture (36)

θj = the parameter conditioned upon the data at hand (37)

Testing a Significant Difference between the Means of Two Cultures

$$\frac{(\theta_i-\theta_j) - (\rho^2)(y_{i.}-y_{j.})}{\sqrt{2\left[\frac{s_1+s_2(1-\rho^2)}{Jk-1}\right]\frac{(\rho^2)}{k}}} \sim t_{JK-1} \quad (38)$$

where ρ^2 = generalizability coefficient (39)

$y_j.$ = mean of "j"th culture (40)

$y_{i.}$ = mean of "i"th culture (41)

S_1 = within groups sums of squares (42)

S_2 = between groups sums of square (43)

J = Number of cultures (44)

K = Number of observations per culture (45)

θ_i, θ_j = parameters conditioned upon data at hand (46)

Testing the Significance of the Difference Between Many Different Cultural Means and the Grand Mean

$$\frac{(m2)(\rho^2)}{\left(\frac{s_1 + (1-\rho^2)s_2}{(JK-1)}\right)} \sim F_{J-1,Jk-1} \quad (47)$$

where ρ^2 = generalizability coefficient (48)

$m2$ = between groups mean square (49)

s_1 = within groups sums of squares (50)

s_2 = Between groups sums of squares (51)

J = number of cultures (52)

K = number of observations within each culture (53)

Similarly, the posterior variance, covariance, and correlation terms can be calculated for a set of cultures means. The posterior variance for a culture's mean from a distribution of a set of culture means can be shown to equal (Box & Tiao, 1973):

$$\mathrm{Var}(\theta_j|\underset{\sim}{y}) = \frac{J(\nu_1 M_1 + \mu_1' \nu_2 M_2) + (J-1)(\mu_1' \nu_1 M_1 + \mu_2' \nu_2 M_2)}{JK(\nu_1 + \nu_2 - 2)} + (y_j. - y..)^2 \mu_2 \quad (54)$$

where

$\underset{\sim}{y}$ = vector of raw data (given)

$\mu_1' = \frac{(J-1)}{(J(K-1)2)}$

$\mu_2' = \frac{(J+1)(J-1)}{(J(K-1)-\frac{4}{2})(J(k-1)-2)}$

$\mu_2 = \mu_2' - (\mu_1')$

M_1 = mean square within cultures

M_2 = mean square between cultures

J = the number of cultures

K = the number of observation within each culture

ν_1 = degrees of freedom for M_1

ν_2 = degrees of freedom for M_2

$y_j.$ = each culture's mean on the dependent variable

$y..$ = grand mean on dependent variable across all cultures.

The posterior covariance between any two cultures' means can be defined by,

$$\text{Cov}(\theta_i, \theta j | \underset{\sim}{y}) = \frac{\mu_1' V_1 M_1 + \mu_2' V_2 M_2}{JK(V + V - 2)} + (y_i. - y..)(y_j. - y..)\mu_2 \quad (55)$$

The posterior correlations among the cultures' means follow directly from the above two expressions and are,

$$R(\theta_i, \theta_j | \underset{\sim}{y}) = \left[\frac{\text{Cov}(\theta_i, \theta_j | \underset{\sim}{y})}{\text{Var}(\theta_i | \underset{\sim}{y}) \text{Var}(\theta_j | \underset{\sim}{y})} \right]^{\frac{1}{2}} \quad (56)$$

V. The Establishment of the Cross-Cultural Equivalency of Psychological Constructs

In addition to the above considerations, the cross-cultural researcher must also guard that the definition of the psychological construct (e.g., achievement motivation) remains the same across cultures. As Cronbach and Drenth (1972) have argued, a researcher can not automatically assume that the same psychological instrument measures the same construct in several cultures. Likewise, Irvine (1973) has shown that even with emic measurements, it is fallacious to believe in generality of human behavior if two cultures had similar mean scores on instruments (e.g., Children's Achievement Scale) purported to measure the same construct. Rather, Irvine (1973), Irvine and Carroll (Note 6), and Irvine and Sanders (1972), hold that a researcher must first demonstrate that the "same score" in two cultures means the "same" thing through a process of cross-cultural validation of the psychological construct of interest. Traditionally, this validation process has been done primarily within the realm of factor analytic methodology (Brulin, Lonner, and Thorndike, 1973; Przeworski and Teune, 1970). Irvine and Carroll (Note 13) and Irvine and Sanders (1972) have expressed a couple new very efficient methodologies to be conducted prior to any factor analyytic work. However, a technique presently known as multivariate Generalizability (Toe and Woodward, 1976)

or canonical reliability analysis (Conger, 1974 Conger and Lipshitz, 1974) can be employed to determine how well responses fro- members of severa- cultures from emically produced instruments do hang together as one homogeneous set. The approach of canonical reliability analysis can be defined in terms of generalizability theory and cross-cultural research in the following way.

Given that an investigator has emically derived a measure "X" in each of several cultures participating in the study, two different correlation matrices across-cultures could be defined for all the "X" emic measures. These matrices are $\underset{\sim}{R}_{xx}$ and $\underset{\sim}{R}^{*}_{\mu\mu}$. $\underset{\sim}{R}_{xx}$ is the traditional correlation matrix among the "X" measure across all cultures included in the study. However, $\underset{\sim}{R}^{*}_{\mu\mu}$ is a correlation matrix among these emic measures of "X," but with the univariate generalizability coefficients for the emic measure in each culture down the diagonal. (Thus, it is a covariance matrix among the universe scores for standardized observed scores.) The univariate generalizability coefficients would express the degree of homogeneity of all the emic items making up the measure in each culture, in light of the $\sigma^2(\delta)$ level for the items within each culture.[4]

That composite of the most generalizable (cross-culturally) emic measures of "X" could be derived by obtaining the eigenvectors in solving the following equation.

$$\underset{\sim}{R}^{*}_{\mu\mu}\ \underset{\sim}{\chi} = \delta^{2}_{N}\ \underset{\sim}{R}_{xx}\underset{\sim}{\chi} \qquad (57)$$

where

$\underset{\sim}{\chi}$ = the resultant eigenvectors

δ^{2}_{N} = the resultant eigenvalue

The importance of the solution to the above equation is that the researcher could quickly determine exactly and efficiently which emic measures of a construct were equivalent. Their information is obtained without the use of several factor analyses, rotations, the invocation of the criteria necessary to guarantee a "good" factor analysis, and avoids such problems as communality estimation, the number of factors, and the ever-present discrepancy parameter (Tucker, Koopmans, and Linn, 1968).

Furthermore, the above multivariate generalizability analysis yields an average eigenvalue denoted as $\bar{\delta}^{2}$ which can be defined as,

$$\bar{\delta}^{2} = \frac{1}{M}\ \mathrm{Tr}(\underset{\sim}{R}^{*}_{\mu\mu}\ \underset{\sim}{R}^{-1}_{xx}) \qquad (58)$$

where

M = the number of emic measures of "X" (essentially also, the number of cultures, since each culture would have one emic measure of construct "X.")

The average eigenvalues $\overline{\delta}^2$ would express the maximum level of cross-cultural equivalence of the construct "X." Thus, it would be a succinct statement as compared to the check points required by the traditional approach (Irvine, 1973; Irvine and Sanders, 1972; Irvine and Carroll, in press) including possibly many correlations among the reference vectors, amounts of variance accounted for, etc.

Having conducted the above canonical generalizability analysis, the researcher could delimit any testing between mean differences on the construct to those cultures whose emic measures of the construct "X" were contained within the composite expressing the maximum amount of equivalence.

However, two caveats concerning the above approach should be noted. First, the researcher should make sure that the "maximally equivalent composite" is associated with a high degree of equivalence ($\overline{\delta}^2$). Second, the above discussion did not mention the case of a known referent or control group. Following the logic of the Irvine, Sanders, and Carroll approach, it would be necessary that a suitable control culture (e.g., the United States) would be included in the maximally equivalent composite, or at least one of the composites of greater magnitude. In that way, a meaningful interpretation to the "equivalency of construct "X" can be made in relation to the definition of the construct "X" in the control or referent culture.

VI. Posterior Density Function for ρ^2

Having computed the generalizability coefficients for each level in the study, the researcher would be concerned as to their reasonableness, given the data at hand. This degree of reasonableness can be assessed by forming the posterior densities for each ρ^2.

It should be noted that the posterior modes of the posterior distributions for the variance components and generalizability statistics of interest can be obtained quite easily. The calculation and obtaining of the modal values (most likely) of the posterior distribution is in actuality based upon the definition of a χ^{-2} variate as

$$\chi^{-2}(X, \lambda, \nu) \qquad (59)$$

where

X = the factor or component of interest

λ = the scale value for a particular χ^{-2}

ν = degrees of freedom for a particular χ^{-2} distribution

The χ^{-2} distribution has the general form of

$$\chi^{-2}(X,\lambda,\nu) = (K) \quad (X)^{-\frac{1}{2}(\nu+2)} \; e^{-\frac{1}{2}\left(\frac{\lambda}{X}\right)} \tag{60}$$

where

K = constant term

The mode (most likely value) of a $\chi^{-2}_{(X,\lambda,\nu)}$ distribution can be calculated by (Novick and Jackson, 1974),

$$\tilde{X} = \frac{\lambda}{\nu+2} \tag{61}$$

Following this definition and discussion of the characteristics of a χ^{-2} distribtuion, the joint posterior density for composite factors of the hypothetical partially-hierarchical model under consideration can be shown to have the form of,

$$p\,(V_T, V_{TC}, V_{Te:c}, V_c, V_{e:c}, V_{i:e:c} \mid \underset{\sim}{y}) \propto \tag{62}$$

$$\chi^{-2}(V_T, SS_T, df_T) \cdot \chi^{-2}(V_{TC}, SS_{TC}, df_{TC}) \cdot \cdot \cdot \cdot \cdot \quad (63)$$

$$\cdot \cdot \cdot \cdot \chi^{-2}(V_{I:e:c}, SS_{I:e:c}, df_{I:e:c}) \quad (64)$$

Thus, the joint mode ($\tilde{V}$) for the posterior distributions for any of the composite factors in the (hypothetical study) partially-hierarchical design can be given by their sum-of-squares divided by the appropriate degrees of freedom plus two. The posterior modes for the hypothetical partially-hierarchical design are as follows:

$$\tilde{V}_T = \frac{SS_T}{df_T+2} \quad (65)$$

$$\tilde{V}_C = \frac{SS_C}{df_C+2} \quad (66)$$

$$\tilde{V}_{e:C} = \frac{SS_{e:c}}{df_{e:c}+2} \quad (67)$$

$$\tilde{V}_{TC} = \frac{SS_{TC}}{df_{TC}+2} \quad (68)$$

$$\tilde{V}_{Te:C} = \frac{SS_{Te:C}}{df_{Te:C}+2} \quad (69)$$

$$\tilde{V}_{i:e:C} = \frac{SS_{i:e:C}}{df_{i:e:c}+2} \quad (70)$$

Note. In this design SSi:e:c is confounded with SS_ε, as is $\tilde{V}_{i:e:c}$ confounded with $\tilde{V}_\varepsilon$ etc.

This posterior modal framework can be extended to any partially-hierarchical cross-cultural design and will hold up as long as the posterior modal values satisfy the order established by the constraints of the model. However, if

the constraint order is violated (e.g., $\frac{SS_T}{df_T+2} < \frac{SS_{TC}}{df_{TC}+2}$), the Bayesian approach would set all composites involved equal to each other and use a pooled estimate for the common value. Thus, if the above hypothetical order violation of the posterior modal values of $\tilde{V}_T < \tilde{V}_{TC}$ did occur, then the Bayesian rule would set $\tilde{V}_T = \tilde{V}_{TC}$ and estimate this common value by pooling

$$\frac{SS_T + SS_{TC}}{df_T + df_{TC} + 4} \qquad (71)$$

Having thus defined the posterior modal values for the composite factors in a design and taking care of any constraint conflicts, the researcher could then proceed to estimate the posterior modal (most likely) values for the variance components in the partially-hierarchical design. This estimation of the modes of the posterior distribution of the variance components is derived from the estimates of the posterior modes of the composite factors of the partially-hierarchical. To estimate the posterior modes of these variance components, which make up the composite factors, the researcher simply proceeds by taking linear combinations of the composites. Thus the posterior modal values for the variance components in the hypothetical partially-herarchical study can be estimated as follows.

$$\tilde{\sigma}^2_T = \frac{\tilde{V}_T - \tilde{V}_{TC}}{(i)\cdot(e)\cdot(c)} \quad (72)$$

$$\tilde{\sigma}^2_t = \frac{\tilde{V}_C - \tilde{V}_{e:c} + \tilde{V}_{tc} - \tilde{V}_{te:c}}{(i)\cdot(e)\cdot(t)} \quad (73)$$

$$\tilde{\sigma}^2_{E:c} = \frac{\tilde{V}_{e:c} - \tilde{V}_{te:c}}{(i)\cdot(t)} \quad (74)$$

$$\tilde{\sigma}^2_{TC} = \frac{\tilde{V}_{TC} - \tilde{V}_{te:c}}{(i)\cdot(e)} \quad (75)$$

$$\tilde{\sigma}^2_{TE:c} = \frac{\tilde{V}_{Te:c} - \tilde{V}_{I:e:c}}{(i)} \quad (76)$$

$$\tilde{\sigma}^2_{I:E:C} = \frac{\tilde{V}_{I:e:c}}{(t)} \quad (77)$$

It is important to note that the solution to any ordering and constraint violation of the composite factors implies that the variance components for the composite factor which is violating the order is estimated as equal to zero. Thus, if as in the above example, $\frac{SS_T}{df_T+2} < \frac{SS_{TC}}{df_{TC}+2}$, hence $\tilde{V}_T = \tilde{V}_{TC}$, then

$$\tilde{\sigma}^2_T = \frac{\tilde{V}_T - \tilde{V}_{TC}}{(i)\cdot(e)\cdot(c)} = 0. \quad (78)$$

After calculating the posterior modes for the variance components in the partially-hierarchical design, the researcher could then proceed to manipulate them according

to the rules of Generalizability theory to form the approximate posterior modal estimates for the appropriate generalizability statistics and coefficients. This manipulation with the posterior modes of the variable components would merely follow the addition and division rules, for the generalizability statistics for sample data alone. Thus the following modes of the posterior distributions ($\tilde{\sigma}^2(\delta)$) for the $\sigma^2(\delta)$ terms appropriate to particular levels of generality or specificity could be estimated by

$$\text{for } \tilde{\sigma}^2_T,\ \tilde{\sigma}^2(\delta) = \tilde{\sigma}^2_{TC}\Big/(c) + \tilde{\sigma}^2_{Te:c}\Big/(e)(c) + \tilde{\sigma}^2_{I:e:c}\Big/(i)\cdot(e)\cdot(c) \quad (79)$$

$$\text{for } \tilde{\sigma}^2_C,\ \tilde{\sigma}^2(\delta) = \tilde{\sigma}^2_{TC}\Big/(t) + \tilde{\sigma}^2_{Te:c}\Big/(t)\cdot(\varepsilon) + \tilde{\sigma}^2_{e:c}\Big/(e) + \tilde{\sigma}^2_{I:e:c}\Big/(i)\cdot(e) \quad (80)$$

$$\text{for } \tilde{\sigma}^2_{E:C},\ \tilde{\sigma}^2(\delta) = \tilde{\sigma}^2_{Te:c}\Big/(t)\cdot(c) + \tilde{\sigma}^2_{i:e:c}\Big/(i)\cdot(c) \quad (81)$$

These estimates of the modes of the posterior distributions of the $\tilde{\sigma}^2(\delta)$ statistics could then be employed to give estimates of the posterior modes (most likely values) for the generalizability coefficients for the variables included within a particular partially-hierarchical design.

CONCLUSION

This paper has presented several facets of a new paradigm from which to conduct cross-cultural psychological research. Unlike the past models guiding cross-cultural psychological research, the new paradigm facilities multiple level investigations by incorporating both culture-specific (nested) and culture-general (crossed) independent variables within its partially-hierarchical framework. Based upon the generalizability analysis, this model generates sequential tests of alternative hypothesis so that the veridical level of generality or specificity of human behavior can be succinctly assessed. Having empirically determined the veridical level of generality, the researcher can then employ a regression equation which is congruent to the level of generality found. Through the use of Bayesian techniques and inference, the new paradigm can produce posterior distributions for the variance components and generalizability statistics in order to evaluate their reasonableness. Similarly, the Bayesian approach incorporates information concerning the level of generalizability in tests between any or all of the cultural means on the dependent variable.

While the hypothetical example presented in this paper was simplified for the sake of clarity, the new paradigm is open to any number of crossed and nested variables. Indeed the author is currently collaborating with Farmer and Maehr.

(Note 3) in employing this paradigm to analyze cross-cultural data on achievement and career motivation which entials two nested and seven crossed factors. It is hoped that this new approach will be adopted by other cross-cultural researchers in order that multiple-level investigations can be accomplished and the veridical nature of human behavior properly assessed.

FOOTNOTES

1. This design is quite simplified for clarity of presentation.
2. $\sigma^2(\hat{\varepsilon})$ and which can be defined as equal to

   where $\sigma^2(\ )$ = variance component for independent variable of interest

   $\rho^2(\ )$ = generalizability coefficient for the same independent variable
3. Hypothetical designs where the variables are culture (V_C), ethnicity ($V_{\varepsilon:C}$), achievement motivation level (V_T), and their interactions (V_{TC}, $V_{T\varepsilon:C}$) and variduct ($V_{i:e:c}$).

Where:

$$V_T = iec\sigma_t^2 + ie\sigma_{tc}^2 + i\sigma^2te:c + t\sigma_{i}^2:e:c + \sigma_\varepsilon^2$$

$$V_c = ie\sigma_c^2 + it\sigma_e^2:c + t\sigma_{i:c:c}^2 + i\sigma^2_{te:c} + \sigma^2_{i:e:c} + \sigma_\varepsilon^2$$

$$V_{e:c} = it\sigma^2_{e:c} + t\sigma^2_{i:e:c} + i\sigma^2_{te:c} + \sigma^2_\varepsilon$$

$$V_{TC} = ie\sigma^2_{tc} + i\sigma^2_{te:c} + t\sigma^2_{i:e:c} + \sigma^2_\varepsilon$$

$$V_{Te:C} = i\sigma^2_{te:c} + t\sigma^2_{i:e:c} + \sigma^2_\varepsilon$$

$$V_{i:e:c} = t\sigma^2_{i:e:c} + \sigma^2_\varepsilon$$

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2. Lewis, Charles. Personal communication. October 15, 1976.

3. Farmer, H., Maehr, M. Cross-Cultural Study on Sex Differences in Achievement and Career Motivation. Study in Process at the University of Illinois under funding from the Midwestern University Consortium for International Activities (MUCIA). December, 1976.

4. The cases where both emic and etic items have been mixed is derived in Fyans (Note 1).

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